

REMARKS

Claims 1-4 and 6-10 remain in the application for further prosecution. Claim 1 has been amended to further distinguish the two Columbus references by incorporating the subject matter of cancelled Claim 5. Claims 2, 3 and 6 have been amended to conform to amended Claim 1.

Rejections Under 35 U.S.C. § 102

Claims 1-3 and 8 have been rejected under 35 U.S.C. § 102(b) as anticipated by Columbus (U.S. 4,233,029). The Examiner has substantially repeated his previous rejections.

Columbus describes a device intended to provide controlled multidimensional flow with a predetermined peripheral configuration (see Claim 1). In other words, liquid added to the inlet port flows across the entire surface by capillary forces as directed by sets of grooves placed at an angle to each other. The present microfluidic device is clearly different, since an enclosed unidirectional capillary passageway connects the inlet port to an enclosed inlet chamber. Columbus teaches the opposite approach, as he directly states at column 6, lines 31-34, “the multidirectional flow achieved by the device as described is the overall flow occurring in two or more non-aligned directions as primarily distinguished from unidirectional flow.”

Claim 1 will be compared with Columbus in the following table, in which the differences will be made clear.

Claim 1

A microfluidic device for assaying a liquid biological sample of 20 μ L or less comprising:

(a) an inlet port for receiving said sample;

Columbus

- Columbus may be considered a microfluidic device, although it uses drop volumes between 5 and 1000 μ L (column 4, lines 45-47), which relate to the purpose of the Columbus device. That is, Columbus spreads his sample over the space between two surfaces, rather than filling an inlet chamber.
- Columbus’s “liquid access aperture 26” is an inlet port and not a capillary passageway, as the Examiner believes. Columbus requires that surfaces 16 and 18 are wetted, which permits them to transport the liquid sample by capillary

action. The inlet port 26 is said to be sized to allow the sample drop to fill the port 26 and the space between the grooved surfaces 16 and 18 (column 4, lines 42-45). Fig. 2 shows a large drop placed on top of surface 24, which is drawn into the space between the two grooved surfaces by capillary action. If the port 26 is too small, both of the surfaces cannot be wetted by the continuous volume of the drop (column 4, lines 35-38). It is believed that Columbus means that a small opening would prevent liquid from exiting into the surfaces 16 and 18 by capillary forces acting at the exit of port 26. On the other hand, if the port is too large, the capillary forces would be negligible and liquid would flow onto the lower surface and not the upper surface (column 4, lines 38-42). In neither case is the liquid drop transported by capillary force along the sidewalls of inlet port 26.

- The problems associated with introducing liquid drops into the capillary space between the opposed surfaces are discussed extensively in his U.S. patents 4,254,083 and 4,439,526 (cited in the recent Information Disclosure Statement). Columbus provides dimensions which make it clear that the entry apertures have diameters much larger than the width of the capillary space, and also that the thickness of the surfaces is very thin compared to the diameter of the apertures. In effect, there is no passageway to provide capillary forces and it is the weight of the droplet that drives the liquid into the capillary space (see column 8, lines 17-20 of the '526 patent).

(b) an enclosed unidirectional capillary passageway in fluid communication with said

- From the discussion opposite (a) above it should be clear that Columbus has no

inlet port;

(c) an enclosed inlet chamber in fluid communication at one side thereof with the enclosed unidirectional capillary passageway of (b);

thereby providing said sample an entry into said enclosed inlet chamber;

said enclosed inlet chamber containing a microstructure comprising a uniform array of posts disposed to force said sample to change direction as it passes through said array of posts across said chamber;

and (d) at least one vent passageway for removing air displaced by said liquid sample

enclosed unidirectional capillary passageway. Instead he combines an inlet port with opposing grooved surfaces that spread a liquid drop in all directions.

- Columbus's space between surfaces 16 and 18 is not enclosed, since it must be open at the edges to allow air to be expelled (see column 6, lines 13-20). The flow of liquid is not unidirectional in Columbus, but multi-directional (column 6, lines 31-34). Furthermore, Columbus design requires entry at the middle of the space in order to uniformly distribute liquid in all possible directions, rather than from one side.
- Columbus has an inlet chamber only insofar as it is a space, but not as an enclosed chamber, which requires that the liquid be confined within the chamber. Columbus indicates at column 10, lines 1-7 that the sample liquid can be distributed at the entire edge 20 or 22. Thus, Columbus's "chamber" does not correspond to the chamber disclosed by the Applicants.
- Columbus distributes liquid across his "chamber", but distributes it 360° from a central location and not from one side of the chamber to an opposite side. He does not employ a uniform array of posts, but opposed sets of grooves instead. Columbus should not be considered to distribute liquid unidirectionally, since he teaches that liquid flows along the grooves and jumps over the edges so that the liquid moves in all directions, depending on the orientation of the pair of grooves on any given devices. (see Figs. 4-6).
- Columbus does not use a vent passageway, but merely allows air to be

at a side opposite the entry of said capillary passageway.

purged at all the four edges of his device. Air is not removed from a side opposite an entry of the liquid.

Columbus clearly intended that liquid added to his device would flow uniformly along the opposing grooves and in so doing force the air out from the space between the upper and lower surfaces, as is obvious from Fig. 1 and the discussion at column 6, lines 13-21. The Applicants' device introduces liquid through an enclosed passageway at one side of a closed chamber and forces air out through a vent located opposite the liquid inlet, and is therefore distinguished from the Columbus device.

However, the Examiner states that "Columbus further anticipates the incorporation of a n enclosed inlet chamber (apertures 26b or 26b') at one side thereof [sic] the device". Further, he states that "Columbus anticipates an enclosed passageway. Walls 124 and 144 enclose passageway defined by 44b (see col. 11, lines 1-16; Fig. 10)." (Note that wall 144 appears only in Fig. 12, where it corresponds to wall 124 in Fig. 10). Figures 10 and 12 are quite different structurally, but they both suggest to the Examiner a closed passageway. However, with a closer review it will be seen that, in order to accomplish the uniform distribution of liquid essential to Columbus, a closed passageway is not created and that the liquid must fill the space between the two sets of grooves.

At column 11, lines 1-6, Columbus states that edge wall 124 is used to create a space between grooves 42b and 44b. Thus, the liquid can, and does, flow along both grooves to fill the entire space, as is described in detail at column 5, line 1 to column 6, line 37. Columbus goes on to say that "Preferably, at least a portion of the space between grooves 42b and 44b is left exposed at edge surfaces by device 10, Fig. 9, whereby air can be vented or expelled as the

menisci advance”. Thus, expelling air at the periphery of the device is still provided. But, even if wall 124 were complete, air could still be expelled through the grooves 44, which are not enclosed by wall 124. Therefore, there is no enclosed passageway which enters a closed chamber and expels air from the side opposite the inlet. The purpose of the Columbus device is to create uniform flow multi-directionally between his opposing surfaces, which, as is discussed in column 1 is intended to overcome problems with earlier devices, such as trapping air and uncontrolled liquid flow.

Columbus also suggests using bridging studs between the opposed surfaces, which would provide space for venting air directly from grooves 42. He notes at column 11, lines 17-30 that uniform advancing liquid wave fronts are needed to provide a stable bias potential. Further, at lines 31-36, referring to Fig. 11, Columbus states his preference for the flow along grooves 42 to fill the entire width from 20b to 20b before the flow along grooves 44b results in the wave fronts meeting at 134. Again, this means that air must be expelled all along edges 20b.

Wall 144 appears only in Example 2 as part of Fig. 12. It appears to be continuous since it seems to direct liquid around corners 140, 142, and 144 into isolated test areas 136 and 138. However, if these test areas are to be filled uniformly from the upper grooves, then air must be expelled from the opposing bottom grooves as in Fig. 10. Thus, the upper grooves do not provide a closed passageway that ends in a closed chamber, as in the Applicants’ device where air inherently is moved ahead of liquid passing through the passageway and expelled, along with air in the closed chamber, at a vent from the chamber at a side opposite the entry point.

That the Examiner gives unduly broad reading of the Applicant’s claims also may be seen by considering whether they would be infringed by Columbus’s device.

Claim 1

- A microfluidic device for assaying a liquid biological sample of 20 μL or less comprising:
- An inlet port for receiving said sample
- an enclosed unidirectional capillary passageway in fluid communication with said inlet port;
- an enclosed inlet chamber in fluid communication at one side thereof with the enclosed unidirectional capillary passageway of (b) thereby providing said sample an entry into said enclosed inlet chamber.
- said enclosed inlet chamber containing a microstructure comprising a uniform array of posts disposed to force said sample to change direction as it passes through said array of posts across said chamber;
- and (d) at least one vent passageway for removing air displaced by said liquid sample at a side opposite the entry of said capillary passageway.

Columbus

- If Columbus's device is assumed to employ much more than 20 μL typically, it would arguably not infringe.
- Columbus does have an inlet port 26 and would infringe this element of the claim.
- Columbus's opening 26, if considered an inlet port, would be contended to not be a capillary passageway, since at most one would have to consider the thickness of surfaces 12 to be a capillary passageway. Furthermore, as discussed above it is likely that a sample drop will be pulled through the opposing grooved surfaces by capillary forces, while inlet port 26 is too large to contribute capillary forces.
- Columbus would contend that his open-sided device was not an enclosed inlet chamber, nor did the space between his opposing surfaces receive fluid at one side from his inlet 26.
- Columbus would point out that his inlet 26 is centrally located and not from one side, so that liquid is distributed in all directions. Furthermore, that he uses opposed grooves, not an array of posts.
- Columbus would contend that his purging of air at all four edges of his device could not be considered a vent passageway or four vent passageways. In particular, that by opposing grooved surfaces, air is moved all directions at once. Its flow is not directed to a side opposite the liquid entry.

The Examiner considers that, in Claim 8, a reagent in the inlet chamber is a process or intended use limitation. Applicants disagree. A microfluidics device containing a reagent in the

inlet chamber is part of the device itself and the purpose of the microstructure of the invention is to assure uniform contact of a sample liquid with the reagent. However, in order to advance prosecution, the Applicants agree to cancellation of Claim 8 by Examiner's amendment, if he rejection is maintained.

Claims 1-3 and 8-10 have been rejected also under 35 U.S.C. 102(b) as anticipated by Columbus, U.S. 4,618,476. Columbus's '476 device is significantly different from his '029 device. He considered it to be an improvement, in which barriers and slots replace the opposed grooves found in the '029 patent. In this device, when two different liquids enter separate openings and move toward each other, the capillary transport zone is sealed at the edges and air is expelled from apertures 60 and 62 (Fig. 5, column 4, lines 53-57). This is also seen more clearly in Fig. 8 (column 5, lines 39-50) where two different liquids enter at two apertures 140 and 142 and meet at the center. Air is released from a series of holes 60, 62.

The Examiner referred particularly to Fig. 16, described at column 7, lines 15-38, which is a device intended to allow two liquids to flow side-by-side without mixing. The liquids are introduced separately through inlet ports 410 and travel along the right and left sides of transport zone 30g. The ribs are not used just to distribute liquids across the chamber, as the Examiner states, but are used to remove air from the transport zone (see column 4, lines 1-5 and 29-33). Columbus brings the two liquids in contact with ion-selective electrodes (ISE) disposed along the passage through which the liquids pass. Columbus sums up at column 7, beginning at line 60 "As a result, two dissimilar but misible liquids introduced into zone 30g via apertures 410 will flow side-by-side, along serpentine paths, producing a junction that approximately bisects apertures 42C and is substantially free of convection mixing. Portions of each liquid, one of

which is a reference liquid, are withdrawn through apertures into contact with their respective ISE's, ...”

Claim 1 will be compared with Columbus '476 in the following table, in which the differences will be made clear.

Claim 1

A microfluidic device for assaying a liquid biological sample of 20 μ L or less comprising:

(a) an inlet for receiving said sample

(b) an enclosed unidirectional capillary passageway in fluid communication with said inlet port;

(c) an enclosed inlet chamber in fluid communication at one side thereof with the enclosed unidirectional capillary passageway of (b);

thereby providing said sample an entry into said enclosed inlet chamber;

Columbus '476

○ Fig. 16 discloses a device for handling two liquids flowing concurrently through the device without mixing (column 7-8). Fig. 8 discloses a device for handling two liquids that flow toward each other.

○ Fig. 16 contains two apertures (410) for two samples not one inlet for one sample. Fig. 8 contains two apertures 140 and 142 for introducing separate liquids.

○ Consistent with the two apertures (410), Fig. 16 shows two passageways in fluid communication with the inlet apparatus. Also true of the embodiments of Fig. 8.

○ Capillary transport zone 30g maintains concurrent flow of two liquids, that flow out through slots 450 to their respective ion-selective electrodes. Although not shown in Fig. 16, air must be expelled through slots 450 for the liquids to access the electrodes. Thus, rather than providing uniform distribution of the two liquids across the transport zone 30g. They are kept separate. The transport zones of Columbus are not enclosed inlet chambers to which liquids enter from capillary passageways. Instead they are capillary passageways entered from apertures and from which air is expelled through slots 450 to reach the ion-selective electrodes.

○ As noted above, the flow of two liquids are concurrent or opposed and not mixed. The objective of the design of the device in Fig. 16 is to deliver the liquids to their respective

said enclosed inlet chamber containing a microstructure comprising a uniform array of posts disposed to force said sample to change direction as it passes through said array of posts across said chamber;

and (d) at least one vent passageway for removing air displaced by said liquid sample at a side opposite the entry of said capillary passageway.

ion-selective electrodes through slots 450. In Fig. 8, the liquids meet midway between the entry ports.

In Fig. 16, the flow of two liquids, which are kept separate, are not distributed uniformly across the transport zone 30g. Where air is purged in Fig. 16 is not clear. In Fig. 8 it appears that air is purged through vents at the top of the transport zone, but in Fig. 16 those vents are not mentioned. The only air vent mentioned is 480 at the end of a waste chamber 470.

The vent in the Applicant's chamber is opposite the entry of their inlet chamber. The only vent identified in Fig. 16 is 480 at the end of waste chamber 470, not in the transport zone 30g. However, it is believed that air must also be removed through slots 450 if liquid is to reach the electrodes. Fig. 8 uses multiple vent openings.

Claim 8 has again been considered a process or intended use limitation. As discussed above, the Applicants consider that reagents in the inlet chamber should be considered part of the device and not a process or intended use limitation.

Rejections Under 35 U.S.C. § 103

Claims 4-6 have been rejected under 35 U.S.C. 103(a) as unpatentable (i.e. obvious) over Columbus '029 in view of Peters, U.S. 6,296,126 B1, the later cited for the use of wedge-shaped cut-out structures. Peters is a co-inventor in the present application, and his patent was cited in paragraph 0037 of the published application (or page 11, line 17). Claims 4-6 (as amended 4, 6) are dependent from Claim 1 and if, as the Applicants contend, Claim 1 is distinguished from Columbus and patentable, then Claims 4-6 should also be allowable. Furthermore, Peters does

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not disclose his posts to distribute liquid uniformly in parallel to the posts, but instead uses the v-shaped grooves as channels for the liquid, so that the structure of Peters is not disposed to force the sample liquid to change direction as it passes through the array of posts.

Peters' invention was intended to solve a problem, namely, how to remove liquid from the exit of capillaries (col. 1, lines 38-41). His solution was characterized by the features described at column 2, lines 13-23. Since the radius of curvature at the wedge-edge is smaller than half the smallest dimension of the capillary, Peters creates a channel with a greater capillary force. Then, when the beginning of the wedge is inside the exit area of the capillary (col. 2, lines 59-61), the liquid is drawn out of the capillary and out through the wedge-shaped channel for collection (column 3, lines 56-60). Thus, the Peters' posts with wedge-shaped cutouts are positioned to direct flow of liquid out of capillaries and the flow is not passed around the posts, as in the Applicants' invention.

Claim 7 has been rejected under 35 U.S.C. 103(a) as unpatentable over Columbus '029 in view of Bedingham et al, U.S. 6,734,401 B2, cited for disclosing a tapered inlet port to engage a pipette tip. Claim 7 should be allowable if Claim 1 is patentable over Columbus.

In view of the above remarks the Examiner is urged to allow the amended claims remaining in the application. If further amendments are believed necessary, the Examiner is invited to contact the Applicant's attorney at the telephone number provided below.

Respectfully submitted,

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Date

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